HOW RADIO TUBES ARE TESTED

LESSON NO. TV-14

Sprayberry Academy of Radio

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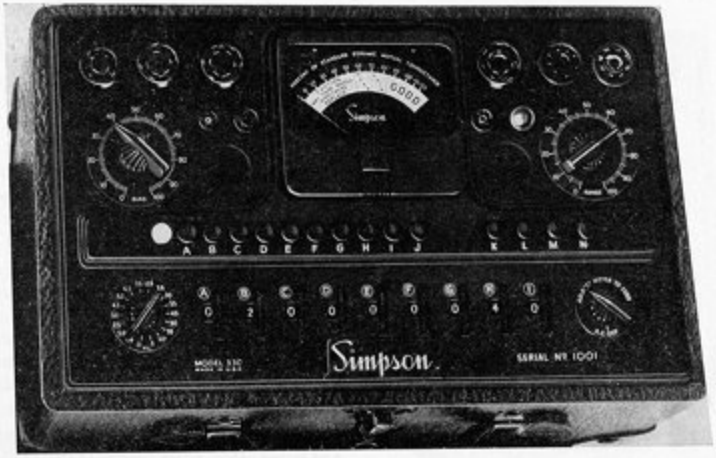


The above photograph shows a manufactured tube tester such as will be found in thousands of radio stores and service shops all over the country. This particular unit is made by Simpson and is their model 330.

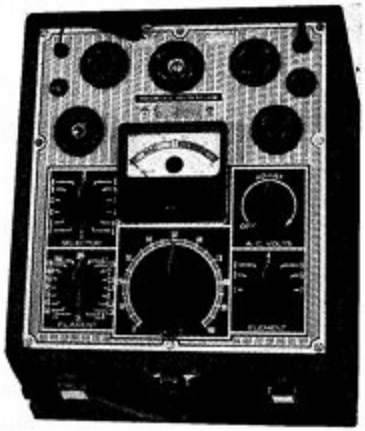
HOW RADIO TUBES ARE TESTED

Lesson TV-14

The radio vacuum tube is by far the most complex single unit used in a radio receiver. Unfortunately from the testing viewpoint, the average tube has a number of characteristics which it is desirable to measure. For amplifier tubes, some of these would be amplification factor, AC plate resistance, mutual conductance, DC plate current, power output, plate dissipation, etc.

Now a tube is designed to operate in a certain way in a radio circuit, and a change in any one of the characteristics as mentioned will have some effect on the operation of the entire circuit in which the tube is used. To correctly test any tube you would need to make an individual test of each important characteristic of the tube. Further along in this lesson you will recognize the importance of the different tests which can be made on different type tubes.

Tube testing is employed by the tube manufacturer and is considered a necessary part of the manufacturing process. It is very important to the manufacturer because of the wide variations which can occur in the making of a product of this type. Although each manufacturing process can be very closely controlled, the finished tube is the result of so many operations that its characteristics may have quite wide variations. As a result, the testing of tubes constitutes a a substantial part of their ultimate cost. A great number of *finished tubes* must be discarded because their characteristics are not within the toler-



This photograph shows a Triplett manufactured tube tester of the portable type. It employs seven sockets and a large square meter which is calibrated in terms of BAD, QUESTIONABLE and GOOD to indicate the condition of the tube under test.

ances required by the manufacturer.

For example, gauging of the wire of which grids and screens are made and size of their diameters can be controlled to better than 1 or 2 %. Likewise, element spacing, material alloy content, welded connections and degree of vacuum can all be controlled within close limits. However, when such a factor as *AC plate resistance* is measured for example, you might find that it is 15 or 20% higher or lower in one tube than in another of the same make and model. The value of the AC plate resistance will depend upon almost all of the factors serving to make up the tube.

Fairly large tolerances in some of the characteristics of a tube may be permitted in order to sell them at a reasonable price and fairly wide variations in many of the characteristics will actually make no material difference in the tube's operation. Such a thing as the filament current depends on the length, diameter and material composition of the filament and on the welded points and leads. For this reason, tubes can be manufactured with filament currents uniform within 2% without much difficulty. Thus, is explained why a 2% change in the filament current of a normally operating tube will make no material difference in its operation.

On the other hand, a characteristic such as the *amplification factor* of a tube is subjected to many other factors in the construction process of the tube and cannot be controlled so closely.

The amount and kind of testing done by the tube manufacturer is quite extensive. If the serviceman had to make such tests, it would require much of his time and the cost of equipment would be prohibitive. Notwithstanding this fact, every serviceman can make satisfactory tests on the average type of tube.

For a number of years *new tube types* have been introduced to the market at an average rate of approximately one every week. For receiving and public address purposes alone, there are some 500 different receiving tube types in use, and new types are still being developed at about the same rate.

This makes it apparent that the more basic the tube testing apparatus, *the more easily it can be adapted to the ever growing list of tube types.* Therefore, basic test methods will first be discussed for determining individual tube characteristics. You will then see how some characteristic tests can be combined in a single test and how various tests are made in the various tube testers in present use.

Manufacturers of tube testers are very much aware of the changing tube design. Therefore, many of the new type tube testers are designed with a separate selector switch which allows for connections between all elements of the tube, reducing the possibility of the tester becoming obsolete. Some tube testers are provided with spare socket buttons so that a new socket can be installed if a new type of tube base is designed that will be different from those already in use.

The Filament Test

Except in rare instances, the filaments of tubes are not directly tested. In all glass tubes, continuity of the filament circuit is assured by the light emitted by the filament when connected to a filament voltage source. Of course, this cannot be done in the case of metal tubes but heat from the envelope of a metal tube is evidence to indicate that the filament is operating. In most tube testers the filaments are supplied with AC from a step-down transformer. Even tubes designed for battery operation may be operated with an AC filament supply for the purpose of testing.

With the low voltage, low current type tubes such as those used in portable battery receivers and in some AC-DC receivers, the filament when burning is not bright enough to be seen and the heat generated is so small that the tube may not heat up enough to be noticeable to the touch. A continuity test across the tube filament pins will reveal any open filament in this type of tube.

To obtain the correct filament voltage for each tube type to be tested the power transformer secondary in the tube tester is tapped for accurate voltages. These voltage taps begin at 1.1 volts and usually include every voltage employed for receiving tubes which have been in use the last 10 years. A representative list of such filament voltages follow in table form:

1.1	5.0	35.
1.4	6.3	45.
1.5	7.0	50.
2.0	7.5	70.
2.5	12.6	85.
3.3	14.0	117.
	25.0	
	30.0	

Besides the list of filament voltages given in the table, there are a few special type tubes using different filament voltages. These tubes are not common, but as they do exist their filament voltage should be known by the serviceman so that he will know what to expect when he encounters an unfamiliar tube. These special tubes have the following filament voltages: 32.5, 28, 20, 21, 2.8, 1.25, 3.2, and .625 volts.

This tube tester is of the large upright type for counter use. The meter is located at the top of the instrument in full view of the customer so that he too may read the condition of the tube under test. Various switches are provided which must be changed for different tube types according to the manufacturers instructions.

In order to get the proper response from each tube under test, it is necessary to have these voltages very accurate. Moreover, it is not possible to put a winding on a transformer and expect it to maintain an accurate fixed voltage under all conditions of load and line voltage variations and also for load variations placed on the transformer by the very tube under test. This involves both a means of adjusting the primary turns-per-volt and a means of measuring or indicating the secondary voltage or the correctness of the primary adjustment.

In Fig. 1 several methods of adjusting the number of primary turns to the line voltage are shown. You are, no doubt, familiar with the fact that the voltage available at an electrical outlet will vary somewhat throughout the day because of load conditions. The power company can compensate for this at the plant but not for the unequal distribution of loads throughout all of their lines. Thus, the line voltage may easily vary from 105 to over 125 volts for a regular 115-117 volt line.

The simplest type of line voltage adjustment consists of using three taps on the transformer as in Fig. 1A for high, low and normal line voltage. This method of line voltage compensation is widely used for receivers but is not considered adequate for modern tube testing requirements. This method may be found on some of the very inexpensive tube testers and is sometimes used for home made testers. The conventional filament switching system is shown with this diagram for the secondary side of the transformer.

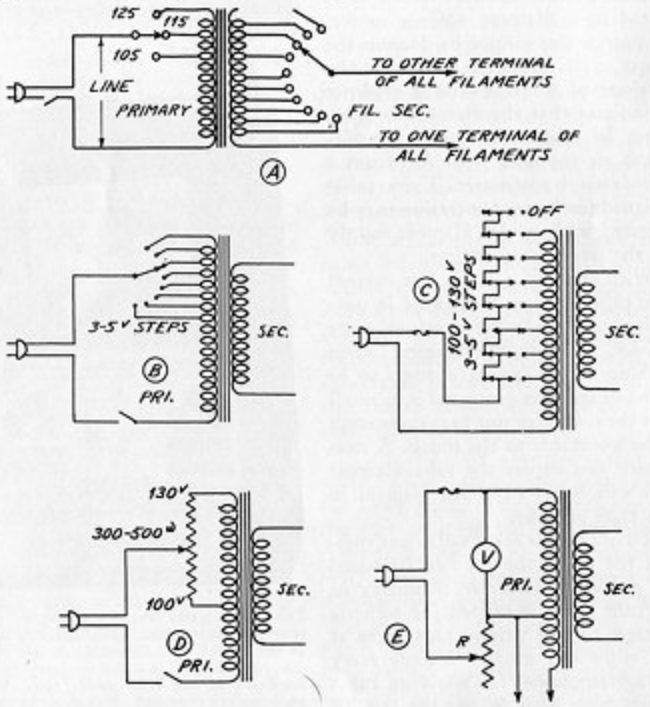


FIG. 1

A more accurate line voltage compensation adjustment may be had by using a number of taps as in Fig. 1B, where a tap is attached at every 3 to 5 volts above 105 volts along the primary. From 7 to 10 taps may be used to extend the range from 100 to 130 volts, and the line compensation is better than 3% for 3 volt taps or 4% for 4 volt taps.

When push-buttons were introduced into tube tester design, this same method was used except that push-buttons did the switching instead of tap switches. A push-button switching system would appear schematically as in Fig. 1C.

Although less efficient, the most rapid and accurate methods appear in Figs. 1D and 1E. It is less efficient because a certain amount of power is wasted in the resistance but this is not objectionable because the tube tester is used for only a short time. It is not turned on continuously like a receiver or public address amplifier.

At Fig. 1D, a 300 to 500 ohm wire wound resistor is connected from a 105 to a 125 volt tap on the power transformer or from a 100 to a 130 volt tap. The movable element of the potentiometer may be adjusted for the exact voltage for perfect line compensation. The variable resistor in Fig. 1E is a series resistor used with a transformer, having a 100 to 105 volt primary. When the voltage is above this value (100 to 105 volts), the resistance is increased to reduce the additional voltage across it. An AC voltmeter is used across the transformer winding in this case to determine the correct setting of the resistor but the voltage need not be measured in this way, as will be explained.

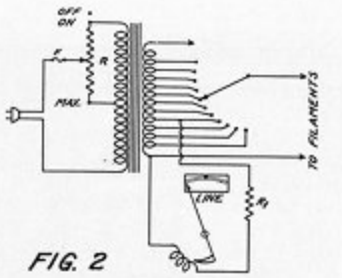


FIG. 2

A load placed on any transformer winding will reduce the voltage of every tap on the transformer. For example, if a load is placed on the 6.3 volt winding of the filament secondary as in Fig. 1A such as to reduce the voltage 10%, it will reduce all of the voltages of the other 17 taps by 10% as well. It is assumed, of course, that this filament winding has 18 taps, as described by the 18 filament voltages in present use.

It should then be obvious that it is only necessary to measure the voltage at one tap to determine the correct voltage for all of them. The minor variations which would enter into the problem may be neglected without reasonable loss of accuracy.

Figure 2 shows an ordinary iron vane type of AC voltmeter connected permanently to one of the filament taps. A fairly low voltage tap is chosen so that the load and hence loss provided by the meter will be negligible. A resistance R1 is then chosen so that the meter will read center-scale or to any predetermined mark

The above view illustrates another manufactured tube tester as made by the Jackson Electrical Instrument Co. Sockets are included for all types of tubes in general use. Just under the meter note the use of the roll type of chart. By turning the control knob which controls this chart printed directions are brought into view for testing the many types of tubes in general use.

on its scale when R is correctly adjusted.

Assume that a tube with a 5 volt filament, such as an 80 rectifier is to be tested. The filament switch is set to 5 volts and the tube is inserted in the proper socket of the tester to be described later. The two terminals marked *To Filaments*, in Fig. 2, supply this tube filament. The line switch is usually associated with the line compensator adjustment R. Note the arrangement of the switch and resistance in Fig.2. The magnetic vane meter, is connected to the 2.5 volt filament winding and will read center-scale, or to any other predetermined mark, when the voltage here is exactly 2.5 volts. The movable arm of R is moved gradually toward MAX until the voltage rises to 2.5 volts at the meter tap, and this means also that at the 5 volt tap the voltage will be exactly 5 volts. Since the tube is drawing its proper filament current as the correct setting is found, the transformer is adjusted under load and since the correct adjustment is always approached from a lower voltage value there need be no danger of overloading the tube. If the line voltage is high (120 to 123 volts) the correct adjustment will be quite near the ON position of R, while if the line voltage is low (105 to 108 volts) the movable arm of R must be moved near the end of its clockwise direction of rotation.

For gas tubes, such as the OZ4 having no filament, the line compensator setting is made simply without placing the tube in the tester. For glass tubes, filament operation can be observed by the light emitted and for metal tubes filament operation can be determined by heating of the tubes. If the tube has not definitely heated in 1 minute, it may be assumed that the tube has a defective filament. In most cases, a half minute is sufficient time to determine this.

If the circuit of any tube is shorted, either the line fuse or a part of the tester will burn out or the correct line adjustment cannot be made. Tube testers are not usually provided with a means of measuring filament current as any serious deviation in filament current from the normal value will be reflected in other tests. For example, if for some reason the filament current is only half normal, the plate current of the tube under test will likely be half or much below half normal if any plate current flows at all. The tube is, therefore, defective and because of this, it does not really matter what the nature of its defect

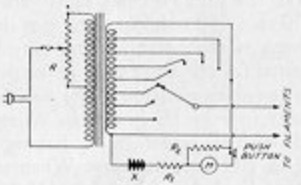


FIG. 3

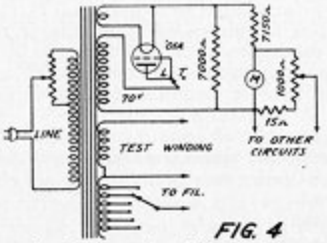


FIG. 4

may be. It must be discarded in any event.

Once the correct filament voltages are found there is no further use for the *line meter*. Thus, instead of using a separate meter for line adjustment, more often the regular meter used in all other tests is used first for line adjustments and then switched to other circuits for other tests.

The regular test meter is always a DC meter because although the AC is not rectified before being applied to the tube under test, the tubes under test serve this purpose so that the ultimate reading is always DC. It is, therefore, necessary to provide a separate rectifier just to operate the meter for the purpose of line voltage adjustment. An application of this method is shown in Fig. 3. The meter circuit is wired across the lowest convenient filament tap in series with a copper-oxide rectifier X and a calibrating resistor R1. Sometimes a push-button is included for line voltage adjustment but usually the selector switch for various testing purposes takes care of this switching. After the voltage is adjusted with the tube to be tested in the tester socket, the meter is switched to other circuits for making tests to be described.

If the meter is an 0-1 or 0-2 milliammeter it will usually require a shunt such as R2 to enable the circuit to draw enough total current through the rectifier X so that it may be depended upon. The characteristics of a copper-oxide rectifier at low currents are not sufficiently constant to be depended upon. Since this involves additional switching it has generally been found more satisfactory to use a tube rectifier for this purpose.

An application of the 01A tube as commonly used in many testers for this purpose is shown in Fig. 4. The tube with grid and plate connected together form a rectifier. It has a separate filament winding of its own as a rule and the transformer is provided with an independent 70 volt winding. This voltage value as well as the resistor values have been chosen for the rectifier tube so that when the correct voltages are at the filament terminals under load, the meter will deflect to a predetermined mark usually indicated as described with a red line or an arrow and marked *Line*. After line compensation has been achieved, the rectifier is simply switched out of the circuit so that the meter is available for other purposes.

Figure 5 shows a method using a 6H6 rectifier for line voltage adjustment. Note that the primary and filament windings are in this case combined into one winding, the transformer acting as an auto-transformer. The 6H6 filament is, of course, permanently connected to the 6.3 volt filament winding. The various other leads go to other testing circuits to be described.

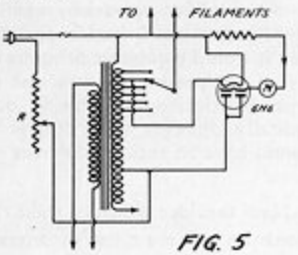


FIG. 5

1. Ep.....Plate supply voltage (maximum or recommended).
2. Ip.....Plate current flow, at recommended plate voltage and with all other conditions under consideration.
3. Esg.....Screen grid voltage (maximum or recommended).
4. Isg.....Screen grid current flow at recommended screen grid voltage and other conditions stated.
5. Eg.....Grid bias voltage (for type of operation stated).
6. Rp.....AC plate resistance (under stated conditions).
7. Gm.....Mutual conductance (under stated conditions).
8. Mu.....Amplification factor.
9. Po.....Power output—watts.
10. Pp.....Plate dissipation—watts.
11. Psg.....Screen grid dissipation—watts.
12. D%.....Distortion percentage.
13. RL.....Recommended load resistance (under stated conditions).
14. Eout.....Filter output voltage of rectifier with inductive or capacitive filter input.
15. Inv.P.....Inverse peak voltage of rectifier.
16. C In.....Input capacity (input to all other elements).
17. C out.....Output capacity (output to all other elements).
18. Cgp.....Capacity (grid to plate).
19. Cgf.....Capacity (grid to filament or heater).
20. Ion.....Gas content of tube.

The many characteristics of tubes which you must know about in order to determine if a tube will work properly in a given circuit will now be considered. Remember that it is never necessary for the serviceman to test all of these characteristics of a tube to determine its condition. The complete list is given, however, for purposes of their relative values in this study. (See the above table).

These are some of the characteristics specified for tubes. Obviously, if you had to test tubes under even one set of conditions such as detector operation, amplifier operation, oscillator operation, class B audio operation, etc., it would require an elaborate outlay of equipment for even one tube type. Multiplying this by 60 or 70 radically different tube designs you would have an entirely different situation.

Now consider which of these characteristics you must test to determine the real worth of the tube. Obviously, the plate and screen voltages are externally supplied and do not have to be tested. At the recommended plate and screen voltages (for screen grid, beam and pentode tubes) and at a recommended bias or class of operation the plate and screen currents will give an idea of the emission of the cathode or filament. In fact, for any positive plate voltage and any positive screen voltage a current will be drawn from the cathode which may be used as a measure of the *electron emission* of the tube. If the emission is only half or one-third normal at normal plate and screen voltages and bias value it will likewise be only one-half or one-third normal at other plate and screen voltage values. Of course, these voltages must not be so high that the maximum emission of the tube or its saturation point has been reached nor too low to get a satisfactory measure of the emission current.

As long as the grid influences the plate current it may as well be connected to the plate, screen and all other elements for the emission test.

Now, if you take a tube to be perfect, such as a type 6SK7 for example, and connect the plate, suppressor, screen grid, and control grid together and impress, for example 20 volts, between this common connection and the cathode with the cathode negative, of course, a certain value of current will flow through the tube. Assume that this is 1.2 milliamperes. Now, if you obtain another tube of this type, make the same connections and also obtain a reading of 1.2 milliamperes, there is at least some probability that the second tube is as good as the first. There is, of course, the possibility that the plate may be shorted to the suppressor, or screen or even to the control grid within the tube. In this case, the defect would not be evident through this test because these elements are connected together.

Typical connections for the emission type tube test are shown in Fig. 6. The setup here shows a test of a tube such as a 6C6. The line compensator R has already been set with the filament switch to 6.3 volts with the tube in the socket. One setting of the selector switch SW1 connects the plate, suppressor, screen and control grid to one terminal of the meter while another connects the cathode to one side of the filament.

A 30 volt transformer winding supplies AC to the tube acting as a rectifier with the meter in series. A push-button is provided which allows the reading to be made.

It would, of course, be possible to use a fixed resistor in place of R1 and then to specify the value of current flow to be expected from *each tube type*. The great variation in current ranges, however, for the various tubes would require more switching for various shunts across the meter. It is, therefore, much simpler to use a potentiometer at R1 and to mark its scale 0-100. For each tube, a number on this scale is specified, which will give exactly the same reading for practically every tube (every one tested on this scale), and the meter range is automatically set in this way.

Since there is a range of values for which a tube may be regarded satisfactory, a large portion of the maximum deflection end of the scale is usually colored green and marked GOOD. This simply means that, if the meter deflection is anywhere within that zone of deflection, the tube may be regarded as in good condition. Below this zone is a narrow yellow segment usually marked DOUBTFUL, while the lower end of the scale (usually the lower half) is marked BAD on a red background.

All tubes with the 6 pin base are placed in this socket (the one shown in Fig. 6) and many of them are tested with the same setting of SW1 but with a different setting of R1. Some of them are tested with a different setting of SW1 because of their base connections with the same or different settings of R1. Other connections of the complete unit which would only confuse this basic circuit have been omitted in Fig. 6.

By use of this circuit the tests for other basic tube characteristics has by no means been exhausted. Only the first five items of the aforegiven table have been combined into one test. Re-

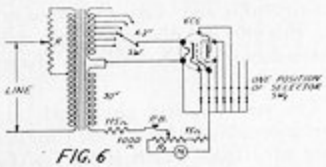


FIG. 6

Here is shown a very popular Philco type of manufactured tube tester. It is push-button controlled as are many of the most modern tube testers. Note the use of blank sockets. These may be removed in case new tube types are brought into use. This makes it possible to provide for new tube types without having to buy a new tube tester.

ferring to the AC plate resistance (Rp), this characteristic of the tube is not tested by the emission method. If the emission test shows satisfactory results, and tests for shorts, leakage and gas in the tube, is at a minimum or shows no indication, you can ordinarily assume that the AC plate resistance of the tube is satisfactory. Since the AC plate resistance depends on element spacing within the tube, and since this also affects the emission, as a rule the AC plate resistance will be satisfactory if the emission is satisfactory.

The emission test gives little information about the *mutual conductance* of a tube which is by far the most important characteristic of any tube having a control grid. The mutual conductance depends on how much change in plate current can be brought about by a given change in grid voltage under certain specified conditions of operation.

Naturally the emission test can give no idea of this fact, but remember what factors affect the mutual conductance of a tube. These are principally the size of the grid, its ratio of open space to wires, its relative spacing from the cathode and plate, spacing of all other elements in the tube, the element arrangement, and type of tube—that is, triode, tetrode, pentode and degree of vacuum, etc.

It should be carefully noted that all of these items are *physical characteristics*, which normally do not change with the operation of the tube. Once a tube has been constructed in a certain way to attain certain operating characteristics, these physical qualities of the tube do not change. Of course, if the tube is severely jarred so that the elements are bent out of position or shorted, or if any of the elements undergo any chemical change which would release gas in the tube due to impurities, the mutual conductance or transconductance will most certainly change. In some cases, such changes will cause the emission to be higher or lower than normal but in other cases they may not.

It is on the basis of the rare probability of this happening, that the emission test can be used to indicate the entire condition of a tube.

Although the emission test will allow for a test of the majority of tube failures, most of the modern tube testers provide a means for checking the mutual conductance. They do not give an actual numerical value of the tube's mutual conductance but a comparison with a standard set-up by the tube manufacturer which will aid in identifying faulty tubes.

The Short Test

A tube must first be tested for internal shorts before other tests are applied. This is specified as a first test because it safe-guards the instrument and meter against damaging currents. The short test, of course, is an essential test for a tube and it is usually worth less if any two of its elements are shorted.

A short test must be applied with the heater under operating condition because this is the way the tube will be used, and it is possible for a short to be formed after the elements are raised to operating temperature due to expansion. It is also possible for two elements to short only when a tube is cold but this is very rare and of little importance if the short is always broken when the tube is heated.

In the rapid development of tube testers there have been a number of methods used for determining shorts. Being based on circuit continuity, they are all basically very simple. The most widely accepted method of short checking in present use is the *neon tube*. One method of its application is shown in Fig. 7. Terminals X and Y are the actual terminals across which a short is indicated. Across the line voltage is placed a condenser C in series with the neon tube circuit R-N and the test terminals X and Y.

Now, if point X is connected to each element of the tube individually, with all other tube elements connected, it can be determined if each element has any direct connection to any of the others. Obviously, if points X and Y of Fig. 7 are shorted, there will be a completed AC circuit producing a large voltage drop across R and the neon lamp. There will be no voltage drop across terminals X and Y and the voltage drop across C at 60 cycles will be very low compared to R. The neon lamp will, therefore, flash 120 times per second for 60 cycles and appear to be lighted continuously.

Connections from each of the socket terminals are brought to individ-

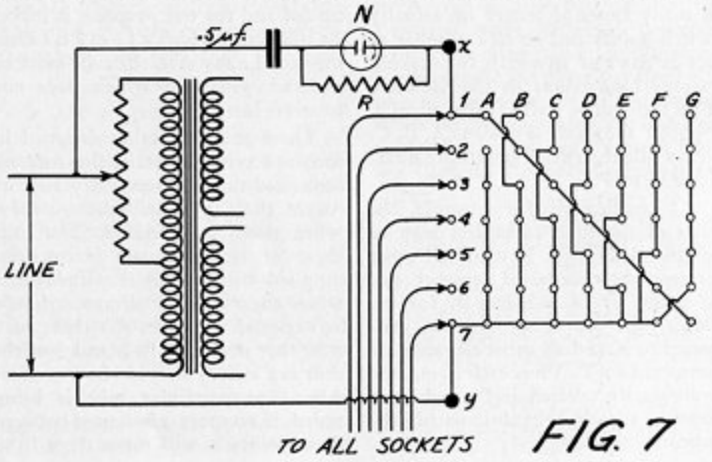
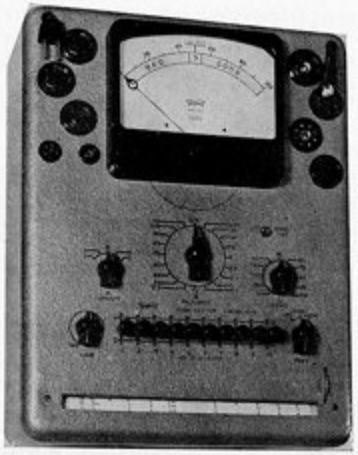


FIG. 7



Above is shown another type of manufactured Triplett tube tester. A large square meter is used and it is calibrated in terms of GOOD, QUESTIONABLE, and BAD tubes. This makes it possible for non-technical help to test tubes because if the simple directions are followed it is no trouble at all to test tubes with this type of tester.

ual switch terminals. These terminals in many types of testers are actually switch points and go to a number of sets or rows of terminals for making various connections to the SHORT TEST circuit as well as other circuits. Figure 7 shows these rows as A, B, C, etc., while the switch points are numbered 1 to 7.

At position A, for example, the plate of the tube under test may be connected to point X while all other elements are connected together and to point Y. In position B, for example, the suppressor may be connected to X and all other elements are connected to Y. Thus each element is individually selected and tested for a short to all other elements within the tube.

As mentioned before, the short test is made while the filament of the tube is in operation. This means that the cathode is active and that for most positions of the switch there will be rectification in one direction or the other, depending, of course, to which terminal (X or Y) the cathode is connected.

For either direction of rectification, however, the condenser C will charge to very nearly peak voltage of the supply and with no appreciable internal leakage will retain that voltage. There will thus be a single flash of the neon lamp due to this initial charging of C and then the neon lamp will go out for the duration of the test. This is perfectly normal operation and does not indicate any defect in the tube.

The neon lamp will almost always flash once as the switch is changed from one setting to the next. If it remains on for any one setting, one of the tube elements is shorted to another. No method is provided for determining which two elements are shorted because this does not matter. The tube is useless for the purpose intended and for test purposes it makes no difference which elements are shorted. In any case, the tube must be replaced with one which does not have an internal short.

There are some tubes designed in such a way that certain elements are connected together internally and, of course, these types will show a short when tested as described. The tube chart or manufacturers instructions supplied with the tester will indicate when these shorted elements should be expected. That is, the chart may state that positions 1, 2, and 3 of the shorting switch should show a short when one particular tube is being tested. If no short is indicated between these points it will mean there is an

open circuit and the tube will need replacing.

Although only one socket is shown in Fig. 7, it must be understood that all of the sockets in the tester are interconnected. Other sections of the selector switch as in Fig. 7, beyond F and G (not shown) can be wired to make connections as in Fig. 6 for the emission test, and still another section can be wired to make the line voltage test as in Fig. 5 or any other line voltage test.

So far, only a small number of the possible tests mentioned in an earlier part of this lesson have been described. The other tests with the exception of the test for *gas content* are of interest to the tube makers only. These characteristics are found by laboratory procedure and it would not help the practical serviceman to know such values as plate dissipation, or distortion percentage, etc. These characteristics are provided by the manufacturer so that the equipment designer may be guided in working out circuit designs. Several of the items, such as numbers 13 and 14 (previously mentioned) cannot actually be called characteristics of tubes, but rather specifications of their operation.

Gas Test

In the manufacture of tubes all possible traces of gas are usually removed in the evacuation process. This, of course, refers to the high vacuum tubes which do not require gas to operate. Certain other tubes, such as the mercury vapor type, the thyratron and the cold cathode rectifier, operate by virtue of their gas content. Thus, this reference refers to the ordinary type of amplifier, converter, detector tubes, etc.

In ordinary use tubes will often *acquire* traces of gas. In some cases this is gas which was absorbed by the metals in the tube in the manufacturing process and in other cases gas is formed by decomposition of impurities in the metals of which the elements are made. This will frequently happen in tubes which have been overloaded.

The presence of gas in any quantity which would affect the correct operation of a tube will cause some amount of grid current to flow with no external voltage applied to the grid but with AC or a positive voltage applied to one or more of the other electrodes. This suggests the method by which a test may be made for gas in any tube.

First it is necessary to connect the grid directly to the cathode and then connect all other elements together and to a voltage source through a meter. Next note the meter reading. Then connect a large resistance in the grid circuit (500,000 ohms) and note any change in the meter reading. The circuit for making this gas test is shown in Fig. 8.

The five terminals of the test selector switch make the proper connections shown and the push-button switch marked GAS TEST is pressed while observing the meter reading. Under conditions of no gas there will be no change in the meter reading, while the presence of gas will be indicated by a change in the meter reading (usually a decrease although not

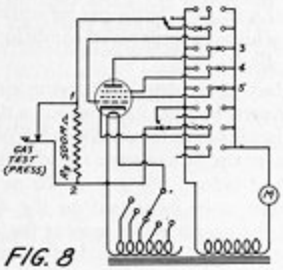


FIG. 8

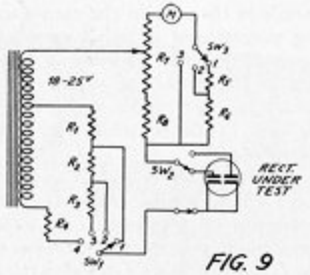


FIG. 9

always so.) Only in the case of a power amplifier can the presence of gas be tolerated, and in this case only where experience shows that it has no ill effects.

Since the gas test is not absolutely essential it will not be found on all tube testers.

Rectifier Testing

Being practically the only possible test which can be applied to a rectifier, the emission test is the ideal one. However, the range of emission currents for all of the rectifiers used in radio is so varied that many circuit changes must be made to test them.

In the first place, for small diode rectifiers, such as the 6H6 or the diode units in various other tubes, such as the 75, the meter is not intended to indicate within its section marked GOOD. The current that a small diode of this kind will carry will deflect the meter perhaps only one-fifth full scale. Instructions with each tube tester will give the proper information by which to judge the condition of the diode.

Part of an actual tube tester circuit is shown in Fig. 9, in which a diode section is being tested. Switch SW1 is part of the test selector switch, as described before and selects the proper voltage to be impressed on the diode and the proper series resistor for each tube group. Terminal 1, for example, would be used for mercury vapor tubes where a low voltage (just sufficient for ionization) is used. A series resistance R1 is used to limit the rectified current to a value which would be safe for the tube and which would fall roughly within the meter range. The higher voltage would be used for high vacuum rectifiers carrying low current.

Switch SW2 of Fig. 9 also a part of the test selector switch, selects first one plate of a full-wave rectifier and then the other as rectifier plates must be tested individually for the proper results. The SW3 section of the switch chooses the proper meter loading in case the current range involved through R7 and R8 does not produce the right voltage drop for the meter.

Mutual Conductance Testing

As outlined in the foregoing, any tube found to have normal emission will usually have satisfactory mutual conductance. Many tube testers are arranged to make this test in addition to the emission test. The great majority of this type of testing is done by the *so called static or grid shift method*. One of the earlier forms of circuits for this test is shown in Fig. 10. A dry cell is included for the grid shift voltage.

The rectified plate current which flows with the grid connected directly to the cathode is first observed and then the grid-shift push-button is

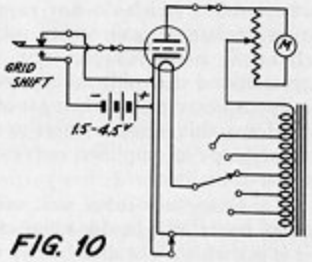


FIG. 10

used to place a bias on the grid. *The new plate current reading is then noted.* The difference between the two readings of plate current is an index of the mutual conductance of the tube.

Unfortunately the applied plate voltage is much smaller than that normally used and is, of course, usually AC. Moreover, the meter is not calibrated to read any specified current in milliamperes. It is adjusted to various sensitivities for convenience of the emission test. When other elements such as screens and anode grids are introduced they do not have their operating voltages applied. These are some of the reasons why this grid shift test is not a specific value but simply a relative measure of the change in the plate current, due to a given change in grid voltage. It is called a mutual conductance test because the mutual conductance of a tube is defined as the ratio of plate current change to grid voltage change.

That is

$$\frac{I_{p1} - I_2}{E_{g2} - E_{g1}} \times 1000$$

$$= \text{Gm (mutual conductance)}.$$

I_{p1} is the initial plate current with a grid potential of E_{g1} and I_{p2} is the resulting plate current when the grid potential is changed to E_{g2}. For an example assume that a 5 volt bias is placed upon the tube (E_{g1}). With this 5 volt bias, 6 milliamperes of plate current flows (I_{p1}); when the switch is changed, a 10 volt bias is placed upon tube (E_{g2}) and 3 milliamperes of plate current flows (I_{p2}). Then the mutual conductance (Gm) is:

$$\frac{6 - 3}{10 - 5} \times 1000 = 600.$$

Another method as shown in Fig. 11 makes use of from 5 to 7.5 volts

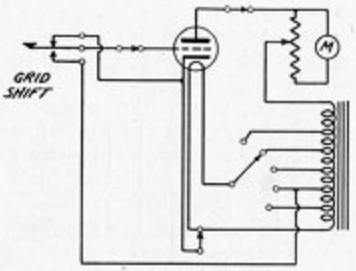


FIG. 11

of the filament voltage for the grid-shift test. Normally the grid is connected to the cathode but when the grid-shift test button is pressed, the grid is supplied with a low voltage AC. This voltage is in phase with the plate voltage, that is, they both reach positive maximum at the same time. The average plate current is, therefore, increased and the increase is a measure of the mutual conductance of the tube.

There are tube testers available which provide testing for the dynamic mutual conductance—that is, the mutual conductance under operating conditions with a signal supplied to the grid and a reading taken of the signal current in the plate circuit. In the static mutual conductance test, two readings must be taken while in the dynamic test, only one reading is needed.

A circuit used in dynamic mutual conductance testing is shown in Fig. 12. Its power supply uses a 25Z5 rectifier which produces a high DC voltage for plate and screen voltage supply and a lower voltage from which a bias may be obtained. Both sections are half wave rectifiers and each has its own complete filter. Another winding produces a total of 18 volts and any AC 60 cycle signal from about 12 volts to zero may be selected from a potentiometer (R1). This

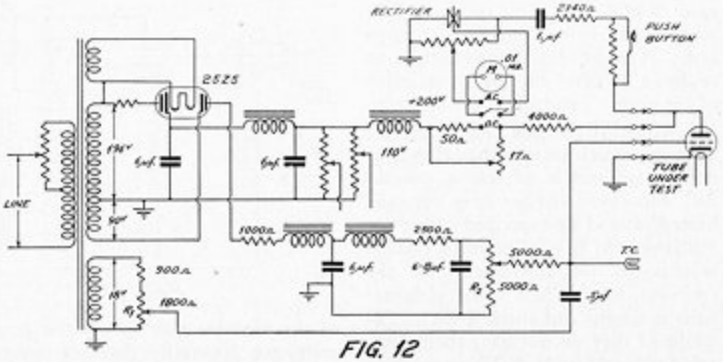


FIG. 12

winding being used for other purposes is larger than necessary for this purpose alone.

Connections in Fig. 12 are shown to a triode tube under test. The 4000 ohm resistor serves as its plate load and another connection to the plate allows a reading of the AC voltage developed at the plate and the current which results from this AC signal voltage. An appropriate bias is selected at R2 and the 5000 ohm series grid resistor serves to isolate the bias supply from the grid signal voltage.

The plate voltage and plate load are at fixed values and if you know the bias and grid signal voltages you can calculate the mutual conductance. Moreover, if the settings of R1 and R2 are specified on a tube chart the mutual conductance may be marked directly on the meter in terms of micromhos.

The difficulty with this type of measurement from a practical standpoint lies in the large range of values which must be dealt with for all tubes. The grid signal voltage of various tubes varies from below 1 volt to 50 volts or more, the plate loads for normal operation varies from a few thousand ohms to over a megohm, and the actual signal at the plate will vary through a correspondingly wide range.

This condition is further complicated by the switching system to make the tester adaptable to all tubes. In addition to this, the mutual conductance of an RF pentode may not indicate as well at 60 cycles as at 1000 KC. In a tube such as the 6K8 the transconductance and translation gains can only be determined through use of the proper frequencies.

Not only the frequency but also the grid, plate and screen voltage of a tube affects its mutual conductance. In other words, the mutual conductance of a tube is far from being a c o n s t a n t. The operating function which a tube is fulfilling determines the value of its mutual conductance and as a given tube can be operated for several different functions the mutual conductance changes for each function making it necessary to know the actual function of a tube to accurately measure the mutual conductance.

For this reason, it is impractical and gives you little information concerning the tube to measure conductance at some specified function. Because of this, most tube testers which give a dynamic mutual conductance test of a tube do not give an absolute value of the mutual conductance but a value which is proportional to the m u t u a l conductance. Some tube testers test a tube under its normal operating conditions. In this way a combination of dynamic mutual conductance and emission test is made at the same time.

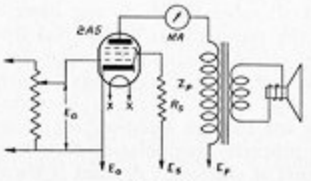


FIG. 13

Figure 13 shows how a 2A5 tube is connected in a typical audio power output stage. The primary purpose of this power tube is to deliver power to the load Zp such that the most electrical power will be applied to the speaker t h r o u g h the transformer. With filament and plate operating voltages applied and with zero signal applied to the grid, the plate current indicated by the plate milliameter will be some steady value depending upon the emission of the cathode and upon the potentials of the elements within the tube. Now by applying an audio signal Eg to the input grid, *the plate current through Zp must vary in accord with the change in grid voltage*. This changing amount is proportional to the dynamic mutual conductance of the tube. The greater the AC grid voltage the greater the AC plate current and accordingly the louder the sound from the speaker.

Now suppose that the peak grid voltage to the tube is in keeping with the operating condition of the tube and all other voltages upon the tube are normal, but severe distortion is produced at the speaker, even though all circuit components are normal except the tube. This indicates that the emission from the cathode of the tube is below normal, causing the tube to overload on the peak excursion of the grid. In other words, there is an insufficient quantity of electrons available to handle the peak power requirement.

Now assume that the same signal as in the previous case is applied to the grid and all the circuit conditions are normal except the tube, yet the output volume from the speaker is much too low. This is due to a low value of m u t u a l conductance. In other words, the magnitude of the plate current variation versus grid voltage is not in keeping with the standard value of mutual conductance of the tube as indicated by the characteristic curves of the tube. This condition can be caused by a multiplicity of internal tube conditions, including open, misplaced and shorted screen grid, control grid, suppressor grid, or plate even though the tube's cathode emission is absolutely normal.

It can be readily seen from the preceding discussion that the condition of a tube is dependent upon both the emission from the cathode and the mutual conductance of the tube. Both of these factors must be considered if an accurate check upon the tube is to be made. The fact that the mutual

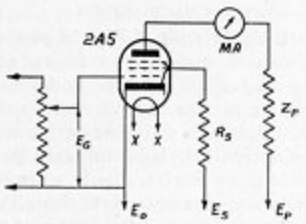


FIG. 14

This type of tube tester is more elaborate than the straight emission type of tester. It is manufactured by the Hickok Electrical Instrument Co. and is of the combination emission and mutual conductance type. Several controls are provided which must be set in a precise way for a given tube type. Specific manufacturers instructions are included with each instrument which tells how to make each test of which the instrument is capable.

conductance is changed due to the physical structure of the tube, it is less likely to cause tube trouble. Therefore, poor emission is by far the greater cause of tube failure.

Figure 14 shows a circuit used to test a 2A5. Note the similarity of the two conditions (Figs. 13 and 14). By testing the tube with the maximum operating conditions as given by the tube manufacturer and in a circuit very similar to the operating condition of the tube both the emission and mutual conductance of the tube will affect the plate current.

With the circuit of Fig. 14 placing the correct operating voltages and plate load upon the tube under test, the plate current as indicated by the milliammeter in the plate circuit will be directly and simultaneously proportional to both cathode emission quality and dynamic mutual conductance; and if the meter circuit is properly calibrated the tube tester will reject all tubes which do not come up to the standards as determined from the original laboratory tests from which the tube chart data is gathered.

The correct operating conditions for the tube in question are secured by properly manipulating the adjustments of the tester. A chart is always provided giving the proper setting for all tubes that can be tested upon the tester. These charts as stated are prepared from extensive laboratory tests upon each tube type. This method of testing will reduce the number of tube failures missed by the tube tester, giving a better average of faulty tubes rejected by the tester.

The Cathode Leakage Test

In a good many radio circuits any leakage between the cathode and heater will cause faulty operation. A good example of such a circuit is a phase inverter, having a high resistance load in the cathode circuit and causing the cathode to operate at plus 50 to 100 or more volts. The filament being at ground potential causes this voltage to be impressed across the cathode-filament electrodes. Another example is in the cathode tap oscillator circuit when the cathode voltage must change at radio frequency.

The cathode leakage test consists simply in disconnecting the cathode while the tube is being given an ordinary emission test. If any plate current remains it is obvious that it is leaking from filament to cathode. Thus, a good tube would indicate no plate current while a poor one would show some current flow even with the cathode curcuit open. Connections for the test are shown in Fig. 15.

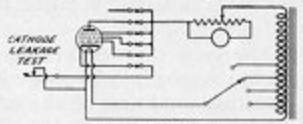


FIG. 15

General Wiring of Tube Testers

Most of the individual tests which have been covered are rather simple circuits. The combination of all of these circuits with a socket for each tube type makes the wiring and switching fairly elaborate. Arrangements must be made to change the filament connections for the octal and loctal sockets as there are five ways to connect the filament in this tube group. As only one socket in the tester is used at one time all sockets may be directly connected. Since the wiring is different for each make and model of tester the manufacturer always supplies charts for setting each of the controls for each tube type.

Recommended Tube Handling Procedure

At this writing there is no substantial sign that the creation of new tube types will not continue as before. Even if there was assurance that no new tube types would be introduced, the present tubes in use will probably be improved, which fact will present practically the same problem as a new tube type.

The nature of tube tester design is such, as a rule, that it is not easily adapted to the testing of new tube types. Perhaps the new tube will be made to fit one of the 7 or more sockets in the present tester but its filament pins may not agree with the wiring of the tester or the general arrangement of wiring of the elements to all pins may not be adapted to the switching systems of the tester.

These facts simply mean that the tube tester has the highest obsolesence of any instrument used by the serviceman. Replacement tubes of the newer types cannot be sold rapidly enough by the small or medium sized business to compensate for the cost of obsolesence of tube testing equipment.

This tube tester is made by the Radio City Products Co. It includes the roll chart feature, push-button switches, the usual selector switches and an adequate number of tube sockets. Like most modern tube testers a large square meter is employed and is calibrated in terms of good and bad tubes.

Many servicemen have learned this by making careful reference to their various costs and have developed a tube handling which avoids the use of a tube tester. While not at all new to the serviceman, this method has not received wide acceptance until recently.

The test consists in substituting tubes in a properly operating receiver to determine the worth of the tube. To the receiver is attached a signal generator connection at the antenna (usually) and the output meter may be used. The signal is, of course, modulated and the output meter is placed across the voice coil. In this way, every tube in the receiver that is not simply a tuning indicator or an intercarrier noise suppressor, etc., will have

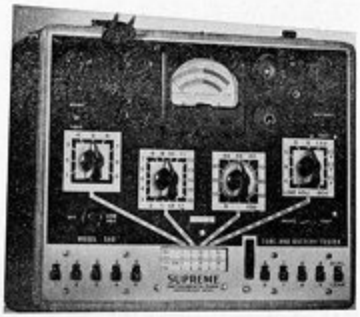
some effect on the ability of the receiver to carry a signal.

Where there is an AVC system used with a receiver, the RF and IF tube faults may not be disclosed because of the AVC action. When the new tube is installed if the AVC is acting properly, the gain of the receiver will be reduced—thus, causing no appreciable change in the output of the receiver. Thus, with these tubes, it may be necessary to stop the action of the AVC while making the substitution tests, or measure the AVC voltage with a vacuum tube voltmeter before and after the new tube is installed. If the AVC voltage increases appreciably when the new tube is installed, it is quite evident that the old tube is weak.

When making a tube substitution test, it is best to make sure that the circuit the faulty tube is removed from is not the cause of the tube failure. If it is, the new tube will be damaged if placed in this circuit before the fault within the circuit is corrected. This difficulty is more prevalent with AC-DC receiver rectifier tubes.

Of course, in cases where a portion of the receiver is not in proper adjustment, the signal can be introduced at any stage and the output meter can be placed at the output of any stage with the necessary adaptations. This, however, is of secondary consideration.

The signal generator output and the volume control of the receiver are adjusted for a satisfactory output and any tube of which there is any question regarding its condition is replaced by another tube selected for this purpose or a new one. For any of the high frequency or low powered AF tubes in an AC receiver the replacement may be made without turning the receiver off. When replacing rectifier tubes, power amplifier tubes or



This is another example of a fine manufactured tube tester. It is made by the Supreme Instruments Corporation. The instrument is arranged for both counter and portable use. It also includes the roll type of chart and modern switching methods. Like all testers of this type the switches must be set in an exact way for each tube type. This is covered by manufacturers instructions.

any tubes in an AC-DC receiver, it should always be turned off while the replacement is being made.

Without any change being made in the volume control setting or signal generator setting, the reading of the output meter is noted and compared with the former reading. In receivers where the volume control and line switch are combined and the receiver must be turned off when replacing tubes, the line cord should be pulled out of its socket so as not to change the volume control setting.

The output meter is, of course, simply an AC voltmeter. If the new tube shows a reading twice as great as the former it simply means that the power delivered to the voice coil has been increased four t i m e s. It also means that the signal output of the new tube is just twice that of the tube which it replaced. This does not mean that the amplification factor of the new tube is twice that of the old tube or that the gain of the stage is twice

that b e f o r e due to the amplification factor of the tube alone. The gain of the stage has been doubled but the former tube may have had the correct amplification factor but with lowered emission. This lowered emission may have affected the AC plate resistance in such a way that the output of the tube has diminished although the amplification factor may not have changed. Just exactly what was wrong with the old or original tube is not of very great importance or interest to the practical serviceman, as he knows that the tube should not be used anyway.

Even this procedure is difficult and costly when it is realized that a good tube of practically every type must be reserved for test purposes. However, it is more practical to buy one new tube when it is introduced than to buy a new tube tester.

While not as perfect an index of performance as r e g a r d s gain and power, the speaker reproduction is more valuable in the tube test than the output meter. Any distortion noted on changing tubes could be identified with the tube changed. The tube substitution method is applicable to *servicing in the home* making use of the reproduction of the receiver entirely without the output meter. This test is superior to any tube test for oscillation because an emission test will not disclose whether or not a tube will oscillate in its proper circuit.

Considerable caution s h o u l d be used in testing tubes by this method of substitution. In addition to the facts mentioned it is not generally wise to replace tubes in a receiver which will not operate at all. For example, in an AC-DC receiver, very often a shorted filter condenser will destroy the emission of the rectifier tube. If a new rectifier is substituted, its emission will likewise be destroyed almost immediately. Be sure that the filter condensers are in good condition before replacing rectifier tubes. This is important in AC receivers as well but is absolutely essential in AC-DC receivers.

The question, of course, arises that if the receiver is not working because of a tube, how are you to restore operation of the receiver before a new tube is tried? In this event, it is a good plan to inspect and test the circuit in some detail to be sure that the tube is not at fault. This may be done by passing a signal around a stage or attaching the signal generator at the in-out circuits of various stages, or in other ways, as described in other lessons. Once assured that the fault lies in the tube, it may be replaced.

If the receiver lacks sensitivity and the tube substitution does not improve it, then obviously the tube is not at fault. Alignment, antenna, etc. would be the first things to check.

The insertion of new tubes in a circuit will in some cases shift the circuit out of adjustment, due to the difference in mechanical structure between tubes. In recent receivers, this is of little importance as tubes have little effect on tuning or adjustment of circuits.

The final or u l t i m a t e test of a tube is its operation in a receiver and this procedure simply omits the preliminary step of the tube tester. It is a procedure well worth considering, but it should be kept in mind that it takes more time to check by this method than when using a manufactured tube tester.

Typical Manufactured Tube Testers

The manufacturers of test equipment are always developing better types of test equipment. This is true

This photograph shows a combination tube and receiver tester. It is made by the Precision Apparatus Corp. and its circuit is shown in Fig. 16. This is an example of putting one instrument to maximum use. The one instrument can be employed to make practically any meter test that is required to be made on a radio receiver.

of tube testers. It is true that the tube tester, due to the many newly developed tubes, often becomes obsolete in a very short time. Manufacturers of tube testers sense this difficulty and for this reason have designed their testers such that they are less likely to become obsolete. This is done by leaving space for extra tube sockets and also leaving extra switching positions on the selector switch.

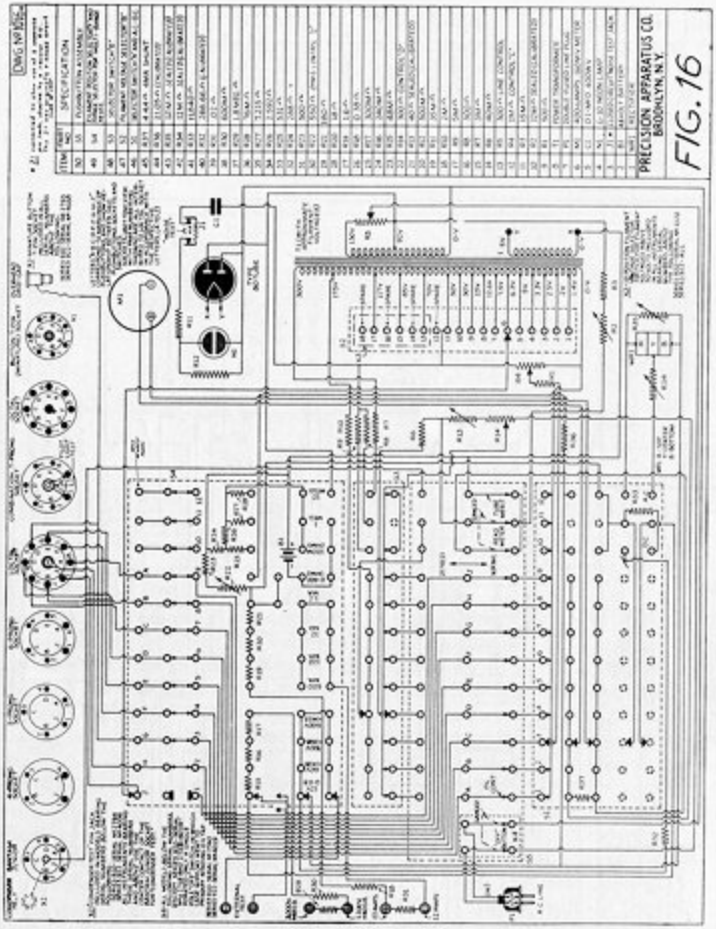
It has been pointed out that tube testers are not always necessary and that many servicemen are using the substitution method of testing because it is a dependable test. As mentioned, if this method of testing is used a complete stock of all types must be on hand. For a serviceman strictly confined to service work, the substitution method of testing may be more satisfactory, but if you run a service shop where you sell tubes, a tube checker is useful in making tube sales. A considerable part of the profit of a radio shop is in the sale of tubes, and as a good share of these sales are made without ever seeing the receiver, the tubes as used in the substitution method of testing is of no value.

It is found by long experience and testing that about 90% of tube failure will be revealed with a simple emission test on the tube. If a tube tester is arranged for an accurate emission test, a good share of the faulty tubes will be caught. A mutual conductance test will increase the tube rejects about 2 to 3% and short, gas, and noise tests will add to this percentage. However, there are still a few tube failures that will not be revealed with a tube tester. A well designed tester capable of accurately making these tests should prove of value to a serviceman where tube sales are a good portion of his profit. Tube testers with a large easily read GOOD-BAD scale is especially adapted to counter tube sales.

There are numerous makes and models of tube testers. Some are more elaborate than others, but in general most of the tube testers on the market will give a fair indication of the condition of the majority of tubes.

For the convenience of the serviceman, many of the latest type tube testers are a combination tube tester and receiver tester. By combining the two units a convenient test instrument is obtained for the serviceman and it reduces the total cost of his test equipment. The advantage of having both instruments combined in one easily portable case allows for a more portable unit when making service calls.

Figure 16 shows a circuit diagram of a typical unit of this type manufactured by the Precision Apparatus

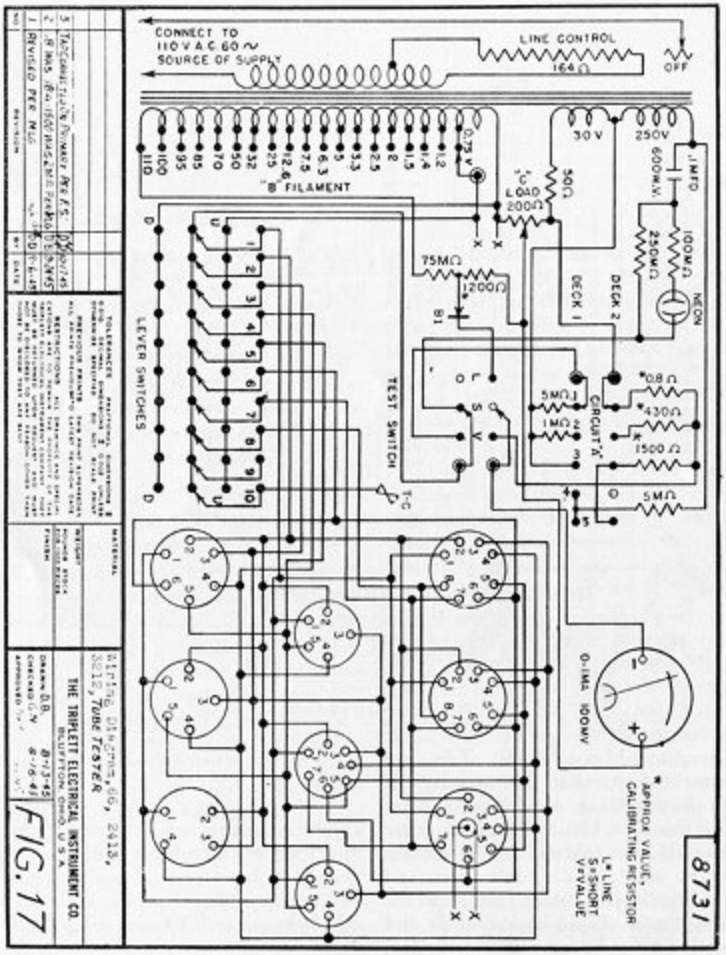


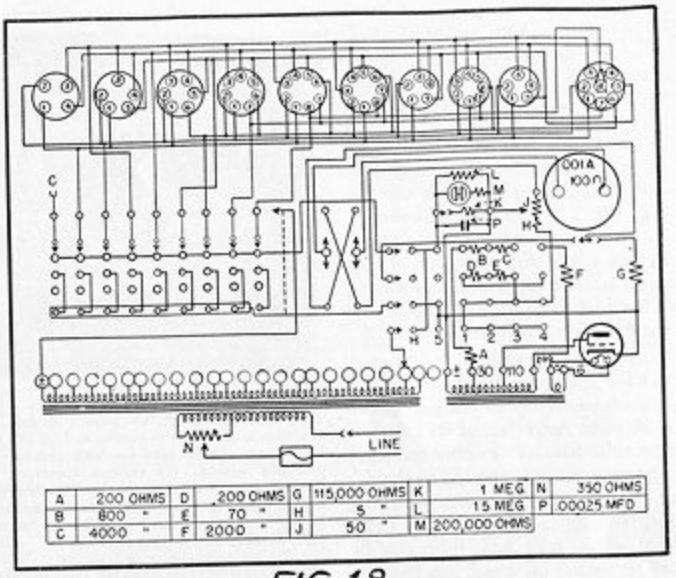
Company, Model 920. The tube tester is designed to accommodate all filament voltage requirements from 1.4 through 120 volts. This tester tests all new loktals, octals, bantam octals, single ended, television and FM amplifiers, bantam junior and the new button 7 pin socket radio and hearing aid tube regardless of the filament or any other tube element positions.

The tube tests include dynamic conductance and emission tests of the operation of the tube, a complete test for shorts between any two elements in the tube, open elements, hot cathode leakage, and a noise test. There are several other features not connected

with tube testing which include battery testing, pilot light testing and a good volt-ohm-milliammeter for receiver testing. The tube testing arrangement is such to minimize the possibility of the tester from becoming obsolete.

Figure 17 shows a circuit of the Triplett Model 2413 tube tester. The filament voltage range varies from .75 volts through 110 volts in 19 steps and makes possible a test of all types of receiving tubes up to date.





A	200 OHMS	D	200 OHMS	G	115,000 OHMS	K	1 MEG	N	350 OHMS
B	800 "	E	70 "	H	5 "	L	15 MEG	P	.00025 MFD
C	4000 "	F	2000 "	J	50 "	M	200,000 OHMS		

FIG. 18

The type of switching arrangement allows an open or short test between any two elements of any tube. It is provided with a spare socket button to allow for any new designed tube, making it less likely to become obsolete.

There are many other tube testers besides these described here, most of which are just as practical and will prove satisfactory within the limits of their design.

To design an accurate tube tester which will give a satisfactory test on all types of tubes, requires considerable research and testing. The actual measurement of the different characteristics of a tube requires a very elaborate tester which incorporates several meters and many controls. This type of tester would be costly, inconvenient to operate and requires considerable time for the test. Thus, they are not practical for a radio serviceman.

The designer of tube testers realize this and try to simulate these tests into one or two simple tests. Although these tests do not actually measure the tube characteristics they will give a good indication of the condition of the tube and will in most cases reveal if it is in operating condition. The serviceman is not interested in the tube's actual amplification factor or its AC plate resistance; he is only interested in the condition of the tube—is it good, bad, or questionable. The only way that a tube tester can be designed that will actually give the operating condition of any tube is to set up a standard of comparison for every tube made and design a tester that will indicate any discrepancies from this standard.

Figure 18 shows a complete diagram of a Simpson Model 305 tube

tester. This tester is provided with eight separate sockets as follows: 4, 5, 6 and 7 pins; also octal, loctal, miniature, and a spare socket is included for any new developments in tubes which may occur. The connections for each tube socket is brought to an individual terminal of a sliding contact switch as indicated to the left in Fig. 18. The upper set of contacts above the sliding switch contacts are not a part of the sliding switch. These controls are the contacts of a rotating switch which is connected to one side of the filament transformer.

This rotating switch provides a means for connecting one side of the filament transformer to one side of the tube filament regardless of its location on the tube base. The other terminal for the filament is connected to the desired filament tap by throwing the sliding switch to the operating position. In this way any tube can be tested regardless of which pin the filaments are connected to on the socket.

There is a meter reversing switch provided with the tester which when in one position allows a measurement of the line voltage so that any correction of line voltage can be made by the line voltage adjustment provided for this purpose. This voltage control

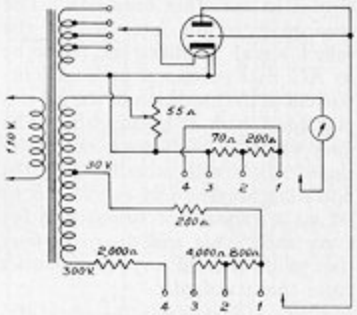


FIG. 19

In the above photograph is shown a panel view of the Triplett tube tester model 3212 the circuit of which is shown in Fig. 17. This instrument can be used for both counter and portable testing. Its various functions are discussed in this lesson. Like all other testers of this general type specific manufacturers instructions must be followed for each type of tube to be tested.

is a variable resistor in the primary circuit of the power transformer and is labelled N in the circuit of Fig. 18. This line voltage adjustment will allow for a correction of the line voltage both above and below the rated voltage of the tester. When the meter reversing switch is in the other position, the meter is used to measure the condition of the tube under test. Figure 19 shows a simplified drawing of the tube testing circuit only indicating how different load conditions can be placed upon the tube under test.

Included in this tester is a neon short test which is unique in that it has two separate sensitivities for the leakage test. This allows for a wider and more exacting short test. The sensitivity is controlled by a switch which is connected to resistor K in the circuit of Fig. 18.

Resistor L is connected across the neon test light all of the time and as it has a resistance value of 15 meg-

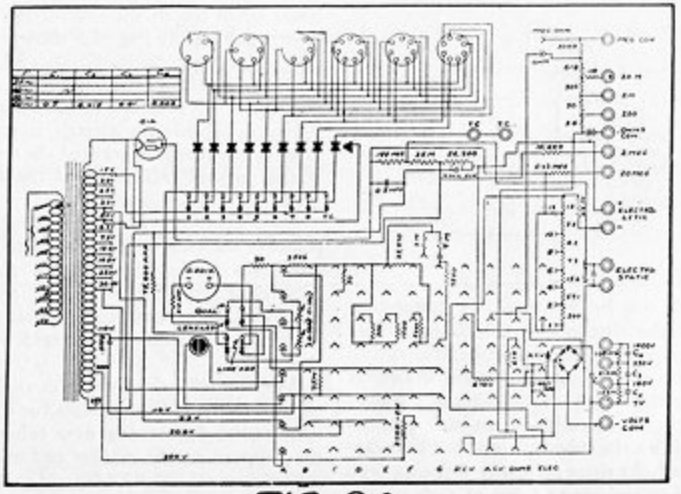


FIG. 20

ohms, the lamp circuit responds to very small element leakage but when the switch which connects resistor K across the lamp is closed the sensitivity of the test lamp is lowered because resistor K has only 1 megohm of resistance.

Figure 20 shows a complete circuit diagram of the Supreme Model 502 tube tester and set analyzer but for this lesson only the tube tester section will be studied.

This tester includes all of the standard tube sockets but has no spare. The switching arrangement of this tester is somewhat different than for the previously described tester but approximately the same tests are made. The total emission of the cath-

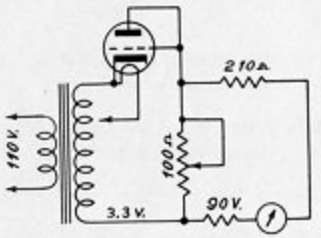


FIG. 21

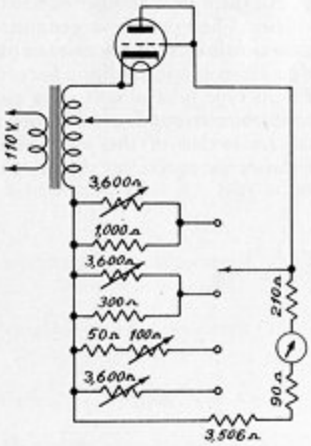


FIG. 22

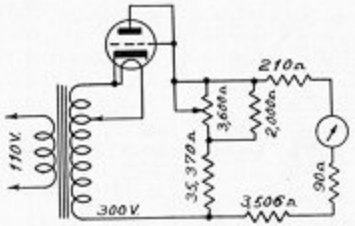


FIG. 23

ode can be measured by connecting all the elements in the tube together except the filaments and cathodes and then measuring the current drawn at certain definite voltages across the tube or separate emission on each element within the tube envelope can be measured. As there are many different type tubes and many tubes of each type it is necessary to make a tester which will allow for the different tubes. Thus, there must be a method provided for several different load conditions to account for all the different type tubes. As seen on the diagram of Fig. 20, there are a number of selector switches. These switches are connected to the circuit in such a way as to provide a different test condition for every different type tube as well as to make circuit connections for using the set analyzer section of this unit. Figure 21 shows the equivalent circuit of the tester when the circuit selector switch is in position A. Fig. 22 shows the circuit for position B, C, D, and E: and Fig. 23 shows the equivalent circuit when the switch is in position F. This circuit selector switch is indicated in the main diagram of the tester at the bottom and center of the diagram.

For each tube type there is a certain position for each control knob of the tester for testing a particular tube. The data supplied with the tester gives the correct control knob setting for every tube that can be tested with this tester.

Most of the tube tester manufacturers supply additional data for their tube testers for testing new tubes as they appear on the market and many manufacturers supply adapters so that their tester will test as many of the newly designed tubes as possible.

Most of the manufacturers of tube testers work in cooperation with the tube manufacturer to determine the limits of their tubes. As already mentioned, it is impossible to design a tester that will reveal all defective tubes. However, if a tube tester is so designed to detect 95% of the defective tubes, it will be of value to the serviceman. Most of the well designed testers will reveal at least 95% of the defective tubes.

These questions are designed to test your knowledge of this lesson. Read them over first to see if you can answer them. If you feel confident that you can, then write out your answers, numbering them to correspond to the questions. If you are not confident that you can answer the questions, re-study the lesson one or more times before writing out your answers. Be sure to answer every question, for if you fail to answer a question, it will reduce your grade on this lesson. When all questions have been answered, mail them to us for grading.

QUESTIONS

No. 1 If the emission of a tube is normal under test, would you consider that the filament of the tube is in good condition?

No. 2 What is done in the tube tester to insure that correct filament and other test voltages will be applied to the tube under test?

No. 3 Why is it that by finding the emission of a tube good, you can usually assume that its AC plate resistances, its amplification factor and its mutual conductance are satisfactory?

No. 4 In the emission tube testing method, how are the elements of any tube connected?

No. 5 Can you determine from the usual commercial tube tester short test which two elements within a tube are shorted?

No. 6 With a neon tube short tester, how is an internal short in a tube actually indicated?

No. 7 Will the presence of excessive gas in a tube cause its plate current to differ with varying grid resistance values?

No. 8 Should the two plates of a full wave rectifier tube be connected together and tested as one plate?

No. 9 Is the grid shift test considered a static or a dynamic tube test?

No. 10 For what purpose is the circuit shown in Fig. 12?